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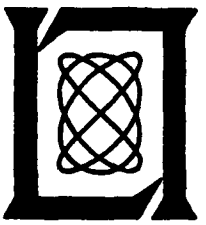
Quarterly Progress Report

Division 3

Radio Physics

15 January 1963

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington, Massachusetts



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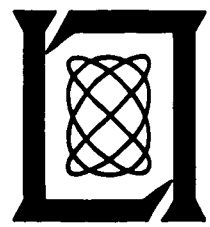

INTRODUCTION

This report summarizes the research and development efforts of Division 3 for the period 1 October through 31 December 1962. A substantial portion of the Division's activities is devoted to the Re-entry Physics and PRESS Programs, reports for which appear in the Semiannual Technical Summary Report and the Quarterly Letter Report to ARPA.

J. V. Harrington
Head, Division 3

T. F. Rogers
Associate Head

15 January 1963

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REPORTS BY AUTHORS IN DIVISION 3

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PUBLISHED REPORTS

Technical Reports

TR No.				ASTIA and Hayden Nos.
272	Radio-Echo Observations of the Moon at 68-cm Wavelength	J.V. Evans	22 June 1962	ASTIA 291102
274	Studies of the F-Region by the Incoherent Back-scatter Method	J.V. Evans	24 July 1962	ASTIA 292730
276	The El Campo Solar Radar Antenna	M.E. Devane A.R. Dion	17 August 1962	ASTIA*
277	A Luneburg Lens as a Passive Reflector for Satellite Communication	R.N. Assaly	21 August 1962	ASTIA 291781
288	Radio-Echo Studies of the Moon at 7.84-Meter Wavelength	J.V. Evans R.P. Ingalls	20 November 1962	ASTIA 294008
290	The Spectra of the Radiation from the Trail of Hypervelocity Spheres in Argon	B.W. Bryant	11 December 1962	ASTIA*

G-Reports

No.				
34G-7	Estimation of the Second-Order Statistics of Randomly Time-Varying Linear Systems	M.J. Levin	2 November 1962	ASTIA 289607 H-445
34G-10	Upper Bound to the Capacity of a Linear Time-Varying Channel with Additive Gaussian Noise	G.D. Forney, Jr.	26 September 1962	ASTIA 287453 H-437
35G-2	Kinetic Theory Description of the Initial Expansion of a Gas Cloud	G. Bienkowski†	2 November 1962	ASTIA 290491 H-446

* Not yet assigned.

† Author not at Lincoln Laboratory.

Published G-Reports (Continued)

No.				ASTIA and Hayden Nos.
36G-1	The Influence of Terrain Shielding on Radio Wave Propagation at 8000 Mcps	W. E. Morrow, Jr. D. Karp R. V. Locke, Jr. W. C. Provencher	20 November 1962	ASTIA 290511 H-452
36G-2	Microwave Cross Section of Thin Dipoles	C. L. Mack, Jr.	15 November 1962	ASTIA 291231 H-458
36G-3	Optimum Satellite Dispensing Velocities for an Equatorial High Altitude Nonsynchronized Satellite Communication System	W. E. Morrow, Jr.	5 December 1962	ASTIA 292995 H-461

Published Journal Articles*

JA No.			
1861	Properties of 400 Mcps Long-Distance Tropospheric Circuits	J. H. Chisholm W. E. Morrow, Jr. B. E. Nichols J. F. Roche A. E. Teachman†	Proc. IRE 50, 2464 (1962)
1916	Some Statistical Properties of Pulsed Oblique HF Ionospheric Transmissions	M. Balser W. B. Smith	J. Research Natl. Bur. Standards 66D, 721 (1962)
1966	Diurnal Variation of the Temperature of the F Region	J. V. Evans	Ltr., J. Geophys. Res. 67, 4914 (1962)
1969	Error Probabilities for Adaptive Multichannel Reception of Binary Signals: Addendum	R. Price	Trans. IRE, PGIT IT-8, 387 (1962)
1983	Spectral Widths and Shapes and Other Characteristics of Incoherent Backscatter from the Ionosphere Observed at 440 Megacycles per Second during a 24-Hour Period in May 1961	V. C. Pineo D. P. Hynek	J. Geophys. Res. 67, 5119 (1962)
1992	Enhancement of Radar Reflectivity Associated with the Lunar Crater Tycho	G. H. Pettengill J. C. Henry	Ltr., J. Geophys. Res. 67, 4881 (1962)
MS-595	Radar Studies of the Lunar Surface	J. V. Evans	NEREM Record (1962)

* Reprints available.

† Author not at Lincoln Laboratory.

UNPUBLISHED REPORTS

Journal Articles

JA No.			
1959	The Computation of Electromagnetic Scattering from Concentric Spherical Structures	J.J. Mikulski E.L. Murphy	Accepted by Trans. IRE, PGAP
1986	The Design of a Constant Angle or Power-Law Magnitude Impedance	R.M. Lerner	Accepted by Trans. IRE, PGCT
1994	The Scattering Behavior of the Moon at Wavelengths of 3.6, 68 and 784 cm	J.V. Evans G.H. Pettengill	Accepted by J. Geophys. Res.
2009	The Microwave Spectrum of Oxygen in the Earth's Atmosphere	M.L. Meeks A.E. Lilley*	Accepted by J. Geophys. Res.
2053	Radar Observations of Venus 1961 and 1959	W.B. Smith	Accepted by Astron. J.

Meeting Speeches†

MS No.			
598	ELF Signals from the Earth-Ionosphere Cavity	C.A. Wagner M. Balser	NEREM, Boston, 5-7 November 1962
606	Some Practical and Theoretical Aspects of Power Spectrum Measurements	M.J. Levin	
617	The Turbulent Wake of Hypersonic Bodies	R.E. Slattery W.G. Clay	17th Annual Meeting and Space Flight Exposition, American Rocket Society, Los Angeles, 13-18 November 1962
645	Radio-Echo Studies of the Moon	J.V. Evans	Colloquium, Cornell University, 18 October 1962
719	Hypervelocity Ballistic Range Measurements of the Electromagnetic Properties of Wakes	E.L. Murphy S. Edelberg G.F. Pippert	AMRAC, Philadelphia, 1-2 November 1962
721	Microwave Radio Astronomy	M.L. Meeks	Physics Department, Georgia Institute of Technology, 17 October 1962

* Author not at Lincoln Laboratory.

† Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

Unpublished Meeting Speeches (Continued)

MS No.			
728	Field Experiments Pertaining to Hypersonic Wakes and Trails	S. Edelberg	17th Annual Meeting and Space Flight Exposition, American Rocket Society, Los Angeles, 13-18 November 1962
731	Radar, Communications and Electromagnetic Waves in Space	J. V. Harrington	New England Regional Conference on Science and Technology in Space, M.I.T., 13 November 1962
755	Optical Aberration Theories for Electronic Computers	D.S. Grey	New England Optical Society, Waltham, Mass., 15 November 1962
761	The Scattering of Radio Waves by the Moon	J. V. Evans	Physics Colloquium, University of Rochester, 14 December 1962
775	Optical Aberration Theories for Automated Lens Design	D.S. Grey	Seminar, Itek, Lexington, Mass., 20 December 1962
778	VHF Radar Measurements of the Solar Corona	J.H. Chisholm	COMPASS Seminar, M.I.T., 18 December 1962

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RADIO PROPAGATION
GROUP 33

I. SOLAR RADAR STUDIES

The regular daily schedule of solar radar observations at 38 Mcps on the El Campo (Texas) radar system was discontinued on 3 October 1962 to permit installation of new data processing equipment; the observations were not resumed until mid-December, following completion of the Venus radar experiment described in Sec. II. Exceptionally strong solar echoes were obtained on 2 and 25 September 1962, when effective radar cross sections of 60×10^{17} and 150×10^{17} square meters, respectively, were measured. The average cross section has been approximately 20×10^{17} square meters. Analysis of data obtained over a period of 62 days and with a one-second range interval shows that, on the average, the solar echoes extend over a range interval of seven seconds (10^6 km). The earliest arriving detectable signals are returned from about 1.85 solar radii from the center of the sun toward the earth; the strongest echoes are from an apparent range of 1.25 solar radii. These values include a correction for 1.6 sec of group delay in the solar corona, computed from theoretical models of the solar corona.

An improved receiver-exciter system for the solar radar was completed and installed during October and November 1962, and was used with modifications during the period of radar observation of Venus. Improved digital timing and control equipment is being designed, and the analog switching and integration equipment also is being revised. After completion of this effort a much more flexible radar system will be available for solar and other radar astronomy experiments.

II. VENUS RADAR EXPERIMENT

A Venus radar experiment at 38.26 Mcps was successfully carried out for the period of inferior conjunction in November and early December 1962. The El Campo solar radar was modified for this experiment and produced long-pulse interval data (2 sec) in real time and short-pulse interval data (1 msec) by magnetic tape recording. The short-pulse data soon will be digitally encoded and processed by the IBM 7090 computer. Coded pulse transmissions that will eliminate problems of range ambiguity, particularly with the short-pulse data, were used throughout.

A preliminary analysis of the data indicates that the radar cross section is of the same order as, if not somewhat larger than, that measured at higher frequencies. Analysis of the short-pulse data, if successful, might indicate whether the reflection at VHF (38.26 Mcps) is ionospheric or from the planetary surface. The analysis and interpretation of the data is currently in progress.

III. LAUNCH PHASE STUDIES

The final report for the launch phase studies is currently nearing completion and will be submitted for publication during the next quarter. The nature of the field measurements and their results are classified.

COMMUNICATION TECHNIQUES
GROUP 34

I. RADAR ASTRONOMY

The last quarterly report* described the improved signal processing equipment and programs to be used with the upgraded Millstone radar for the following observations on Venus: (a) coherent processing of runs using 1/2-msec pulses for range and Doppler observations over a large fraction of the Venus orbit and (b) coherent processing of runs in which range resolution of 20 μsec is obtained with a train of coded 2-msec pulses (using the AN/FPS-17 matched filter). The object of the second set of observations is to generate high-resolution profiles of echo power vs range and to perform high-resolution range-Doppler mapping of the target.

At the present time, all the signal processing equipment has been built and tested, but delays in the availability of the new antenna have made it impossible to obtain data of the second type during the current approach of Venus. Type (a) observations will be attempted soon and the type (b) equipment will be available for the June 1964 Venus conjunction.

II. ELF NOISE OBSERVATIONS

The present spectrum-monitoring filters include post-detection RC networks with a time constant of 40 sec, which is sufficient for monitoring diurnal amplitude fluctuations of individual modes. However, the position of the maximum of a peak in the spectrum is very sensitive to errors in measured power. For this reason, the greater accuracy that results from longer integration is desirable for studying fluctuations in the peak frequency. Consequently, an improved detector and a long-time integrator are being constructed as an adjunct to each spectrum filter. Integration times of 3 or 15 minutes will be available, and a sample every quarter-hour will continue to be the normal mode of operation. Continuous chart records will still be made of the present 40-sec integrator outputs of spectrum filters tuned to key frequencies.

III. COMMUNICATION AND DETECTION THEORY

In a recent report Price† derives the theoretical improvement (in terms of either a reduction of the bit-error probability or a saving in signal power) that can be realized if a receiver derives a phase reference by measurement over preceding bauds; his results apply directly to the case of a binary signaling alphabet with orthogonal equal energy signals and additive "white" Gaussian noise.

With orthogonal signaling, measurement over preceding bauds is easily implemented. For example, with matched-filter detection, the outputs from the mark and space filters are added, sampled at the end of each baud and added to the weighted sum of like samples from previous bauds. The resulting measurement is invariant for the particular binary sequence that has been transmitted.

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* Division 3 Quarterly Progress Report [U], Lincoln Laboratory, M.I.T. (15 October 1963), p. 3, ASTIA 289814.

† R. Price, "Error Probabilities for Adaptive Multichannel Reception of Binary Signals," Conference Paper presented at Int'l Symp. on Info. Theory, Brussels (3–7 September 1962); addendum, Trans. IRE, PGIT IT-8, 387 (1962).

For anticorrelated signals (phase-reversal signaling), the received signal phasors can not be added directly; in order to obtain the increase in detectability afforded by extended measurement, "decision-directed" measurement must be employed. That is, the receiver measures the phase of the incoming baud, decides whether it is more nearly in like phase with or opposite phase to the reference, then adds it into the weighted reference, inverting if the decision was "opposite."

So long as no errors are made, a true average of the incoming phase is obtained; bauds received in error, however, are added into the reference memory in the "wrong" phase. It is interesting to determine the effect of such decision-directed measurement on the error rate at relatively high-error rates (at low-error rates the effect should be negligible).

The problem does not appear to be mathematically tractable; therefore, a communication system employing phase-reversal signaling with synchronous demodulation has been simulated on the IBM 7090. Two types of weighting into the past are used, either a rectangular or an exponential weighting of previous bauds. Programs have been written and the simulation results will be available shortly.

IV. BOMB-QUAKE DISCRIMINATION

A small effort involving several staff members from various groups in the Laboratory is currently under way on the Vela Uniform signal discrimination problem. Vela Uniform is the name given to the study of methods of detecting underground nuclear explosions. The most promising class of approaches involves some form of processing of the electrical outputs of seismometers to distinguish bomb signals from earthquake signals. It is almost certain that a successful discrimination technique will have to involve, at some point, a human appraisal of data, rather than entirely automatic machine methods.

We have made an introductory study of the technical issues as they have been pursued by others, and are now engaged in further study. We are attempting to cast the Vela problem in terms that are more familiar to us, specifically, as a problem in the estimation of the behavior of some source function of time and position that drives a dispersive multipath medium (in this case non-time-varying but known only probabilistically) that in turn drives the receiver or receivers. Also entering the receivers (seismometers) is an additive noise component (microseisms); currently our interest centers on deriving a realistic noise model for an array of spaced seismometers. Study of the literature on this subject is proceeding, but it appears that this soon must be supplemented by our own examination and perhaps computer processing of borrowed data.

V. MISCELLANEOUS

Previous work on the design of lumped-element networks with an impulse response that makes an optimum approximation to a rectangular pulse has been extended to networks whose transfer functions have (a) two poles and one zero and (b) three poles and two zeros. The designs are optimum in the sense of maximizing the output signal-to-noise ratio when used as a "matched" filter for a rectangular pulse. The design procedure involves a computer-aided search for optimum parameters.

PLASMA PHYSICS
GROUP 35

I. LAUNCH PHASE SIMULATION

A. Exploding Sphere Experiment

Initial studies of the propagation of the spherical shock wave into low-pressure environments between 10 mm and 2 mm Hg and below 100 μ Hg have been completed. The formation of the spherical shock has been observed by positioning the pressure-sensor probes at various distances from the center of the shock sphere. At a chamber pressure of 4 mm, a sharp rise indicative of a definite shock wave structure has been observed 5 cm from the center of the sphere, as predicted by the continuum theory of the spherical shock. At pressures below 100 μ, a slow rise has been observed, indicative of a more diffuse shock wave structure. Photographs of the shattering of the shock spheres and the initial escape of the CO_2 from the bulbs have now been made using the schlieren system, and in some cases a somewhat spherical formation of the emanating shock wave has been optically observed.

Studies on the ionization of air within the cavity have been started. The cavity has been pulsed at pulse repetition rates from 50 to 300 at 6-μ pulsewidths, and discharges were observed at chamber pressures from 10 mm to 2 mm Hg. Operational problems with respect to breakdowns in the coaxial lines or at the loops have been solved satisfactorily.

B. Calibration of Pressure-Sensor Probes by Shock Tubes

Tests have been conducted in the low-density shock tube (2 feet in diameter and 60 feet long) of Avco-Everett Research Laboratory, Everett, Massachusetts, to measure the sensitivity of piezoelectric pressure gauges. These are the pressure-sensor probes that are to be used in the exploding-sphere experiment. In these calibration experiments the probe was mounted so that the pressure-sensitive element was located at the stagnation point of a blunt body in the flow stream behind normal shock waves.

The measurements were made in argon at shock-tube pressures from 1 mm Hg to 20 μ Hg. The corresponding shock wave Mach numbers at these pressures ranged from Mach 9.2 to Mach 10.4. The pressures behind the shock wave to which the pressure-sensor probe was exposed covered a range from 9 mm to 500 mm Hg. The sensitivity of the probes was found to be constant at 4 μv per mm Hg, as expected from previous acoustic calibration. However, at those conditions where the Reynolds number of the flow was small, indicative of a transition flow regime, appreciable deviation from this constant was observed.

In order to resolve this discrepancy, calibration of the pressure-sensor probes is being continued with a series of experiments in a shock tube at the Harvard College Observatory, Cambridge, Massachusetts. These experiments are designed to measure the response of the probes at grazing incidence as well as normal incidence.

COMMUNICATION SYSTEMS
GROUP 36

I. PROJECT WEST FORD

A. Camp Parks Site

A 20-foot addition has been placed on the eastern end of the building for a new 420-kw power supply made by Radiation-at-Stanford, Stanford, California. This supply, which can operate to 10.5 amp at 40 kv and to 18.2 amp at 23 kv, has been installed. A new 10-beam 40-kw klystron tube at 8350 Mcps, built by the General Electric Company, has also been installed and operated.

The feed system has been converted from linear to circular polarization with transmitting on right circular and receiving on left circular polarization. Therefore, mechanical rotation of the feed systems is no longer necessary.

B. Millstone Hill Site

The 75-kw power supply that was at the Camp Parks site is now installed and ready for test, replacing the original 36-kw unit. The new supply has a capacity of 25 kv at 3 amp and will operate a 25-kw tube (Varian Model 849) at 7750 Mcps.

A new circular polarization feedhorn having the same configuration as that at Camp Parks has also been installed.

C. Dipole Package

The canister housing, spring drive and dipole decks have been redesigned. Tests are now being conducted on this new package. The dipole decks have been manufactured under subcontract by Wabash Magnetics, Incorporated, Wabash, Indiana. Although some problems were encountered, tests on the dipole decks have shown them to dispense satisfactorily. A rigorous environmental test program on the dipole packages, canister and telemetry has been completed. This included e^- and p^+ irradiation equivalent to a 100- and 500-day dosage. No deleterious effects were noted.

D. Vacuum Test Facility

A high-vacuum space simulation chamber is being planned for installation in an extension to the existing building E. Building drawings are completed, and construction has begun. The chamber is almost finished, as well as the solar-simulation system and the liquid nitrogen cooling system. A liquid nitrogen supply system is being planned.

E. Telemetry Package

The designs of the "round" (as used in April 1962) and of the "square" (new) telemetry packages differed little in their basic approaches. Both used solid-state 240-Mcps crystal-controlled transmitters that deliver 250 mw for over 200 hours at an average duty cycle of 2 percent. A metal disk suspended 2 inches from one end of the "round" package was electrically driven against

the rest of the package to simulate a radiating dipole. The antenna system used with the "square" package differed considerably in that it was comprised of a radiating quadruple antenna driven so as to radiate a uniform pattern.

Spin rate, tumble rate, temperature, sublimation rate of the dipoles, evenness of the sublimation, and logic circuitry supply voltage are measurements transformed into pulsewidths and pulse spacings by the logic, which in turn gates the transmitter. Three pulses per clock cycle carry this information, and a fourth "signature" pulse is added to maximize the reliability of tracking. The pulsewidths range from 3 to 15 msec to permit the use of receiver narrow-band filters of 3 kcps and 10 kcps, maximizing signal to noise. This range selection also permits the duty cycle to be reduced to 2 percent with a 1-cps clock rate. The primary sensors are spin and tumble accelerometers, thermistor networks, zener diode references, four-layer photo-triggered transistors and cylindrical plunges. The power supply, occupying 60 percent of the usable volume, is comprised of Ag-Zn batteries. The designed and successfully tested operating range of the telemetry units is from -50°C to + 50°C.

In the square canister configuration, a prototype and two other environmental-calibration test units have been constructed. All three of these models have been assembled, dismantled and reassembled several times. A majority of the environmental checks have been made. Although difficulties have been encountered, especially in the mechanical assembly of the system components, the results of the environmental test program have been very satisfactory.

The components for the first flight payload and backup have been constructed and tested. Barring unforeseen difficulties, the first flight unit should be completed in the early part of the next reporting period.

II. VENUS EXPERIMENT

In November and December 1962, an attempt was made to bounce signals off the planet Venus, during close approach, by transmitting 40 kw CW from the Camp Parks site and receiving at the Millstone Hill site. The boresight was checked at both sites radiometrically and aiming was monitored (during good weather) by a closed-circuit TV system on the antenna. The receiving system noise temperature was about 60°K and included a maser. With a 40-cps receiver bandwidth and post-detection integration of 50 sec, signals as weak as -177 dbm were detectable. This performance was achieved, however, only when the planet was at a distance of about 40 million miles (closest approach was about 25 million miles on 13 November 1962).

Calculations based on a 10-percent reflectivity of the planet resulted in an expected signal level of -157 dbm at closest approach with 40-kw transmitting power but only -166 dbm at 40 million miles with 34-kw transmitting power. This was, indeed, the case.

To prove equipment performance, signals were transmitted from Camp Parks via the moon at a power level of only 5 mv; a detectable signal was received at Millstone Hill, 69 db down from full power.

The conclusion that can be made from this experiment is that the reflectivity of Venus at 8350 Mcps is less than 10 percent.

III. ADVANCED AND THEORETICAL STUDIES

A. Delay Line Filters

It has been found practical to cascade at least five 96-tap acoustic delay lines to obtain an operational chirp-filter audio dispersion of 75 msec over an 800-cps bandwidth. Each of these lines is of a type described in earlier reports; the acoustic delay is obtained in a thin stretched wire, and the tap weights are set in magnets arranged along the wire. The magnets are held on cards and the tap weights can be set to ± 5 percent in a few minutes by using a special magnetizer. Five such lines, each with a delay range of 20 msec, have been operated in the chirp spectrum analyzer described earlier and employed in the Venus experiments reported above. A set of lines is under construction, each with 192 taps, a delay range of 8 msec and a bandwidth of 15 kcps.

The problems accompanying the desire to approximate to a specified frequency response with a filter transient response of fixed duration have resulted in a 50-percent loss in using the available TW product of the lines. Theoretical studies suggest that much of this loss can be recouped with the aid of a computation routine now in preparation.

B. Linear Phase Filter

Computer calculations have been made that facilitate the design of lossless and nearly lossless linear phase filters. Network transformations have been developed that show the effects of stray parameters on the design; in particular, stop-band zeros can be added without adversely affecting in-band performance.

IV. ACTIVE COMMUNICATION SATELLITE PROGRAM

Recent development efforts have been in four general areas:

(a) The construction of a feasibility-demonstration system model.

(b) The design and specification of a nonflyable prototype model.

(c) An investigation of existing and proposed semiconductor devices suitable for use in the satellite.

(d) An investigation of frequency-converter and multiplier techniques.

System frequencies for the feasibility-demonstration model were selected on the basis of component availability rather than optimum system performance. The model was constructed by using commercially available components with the exception of the output frequency up-converter, the RF power source and the power stage of the intermediate-frequency amplifier. System output power is 12 mw for about 21 watts of DC power. No attempt was made to reduce DC power requirements. Total weight is about 20 pounds, but again no steps were taken to reduce system weight.

A nonflyable prototype unit will be constructed during the next reporting period. System frequencies of the proposed unit differ from those of the feasibility model and represent a compromise between component availability and system performance. Many of the system components are standard or near-standard production units. Weight and power of this system will be kept to a minimum. System output power is expected to be 100 mw for 15 watts of DC power.

Investigations conducted [items (c) and (d)] indicate that the expected efficiency of the nonflyable prototype is realistic. However, development effort will be required, especially in

critical system components areas such as frequency converters, frequency multipliers and high-power sources. The fundamental system problem is efficiency, and the expected efficiency is intimately related to the availability of improved semiconductor devices.

V. ACTIVE SATELLITE ELECTRONICS

A design study has been completed covering major phases of the electronics. In support of this study, development is under way on high-efficiency exciters, IR switching systems and minimum-mass frame design. In addition, sample solar panels, final up-converters, multiplier chains, high power DC-to-AC converters and "critical" solid-state components are being procured.

VI. MARINER B

During this period work has been completed in connection with the Mariner B Venus plasma probe. The prototype, along with a complete set of ground system environmental test equipment (GSE), has been delivered and the contract fulfilled.

This 450-transistor, 9-lb, 2-watt electronic system is intended to "fly" in 1964 aboard a Venus-bound Mariner B spacecraft to measure the properties of the interplanetary solar plasma.

The experiment carried as primary detectors: (a) one large, "6-inch, split collector, proton," Faraday cup, (b) three small "4-inch proton cups" and (c) one "4-inch electron cup." The detectors and detector electronics, along with the switching and control electronics, were designed to work with the spacecraft central data-automation and telemetry systems.

VII. DIAMOND AMPLIFIER

The "Diamond" amplifier has been extensively tested in the hardware stage. Effects of temperature, transistor types, gate drive currents, gate pulselength, holding capacity, gate generation techniques, transistor interchangeability, Diamond circuit configuration and feedback on performance have been investigated. On the basis of these findings, it was concluded that this device is well suited for computer use and offers many advantages over similar devices.

Several basic circuit configurations using the Diamond as a building block have been built and tested. Some of these have been incorporated into equipment at various sites. As a computer element, its performance as a voltage amplifier in several configurations has been demonstrated to conform closely to theory. A multi-input signal adder has also been shown to be feasible.

Experiments have been conducted using nonideal transistor types and no matching. Performance will be enhanced considerably by using newly developed types packaged in matched complementary pairs, soon to be delivered. This will permit the testing of more exotic circuits, with the Diamond as a basic building block.

VIII. HIGH-POWER PULSER

A high-power pulser for driving laser diodes has been developed, built and tested. This unit is capable of 4-μsec output pulses of 160 kw into a 1/4-ohm load. The circuit is similar to that of a conventional line-modulator using resonance charging. The discharge device is a silicon-controlled rectifier (SCR) driven from a General Radio 1217B pulse generator. A 2-to-1 matching transformer is used, together with a 9-section, 2-μsec, 1-ohm delay line.

It was at first anticipated that several SCR's would have to be series-connected in order to handle the power, but experiments showed that a single (Texas Instruments, Inc.) 2N1595 rectifier has a voltage rating of more than 900 volts and has a device drop of a few tens of volts with a 400-amp discharge current. (This device is rated as a 1.3-amp rectifier at 50 volts. Obviously, not all units of this type will have such a high voltage rating, but a surprisingly large fraction falls above 200 volts.)

The nature of service does not require long periods of high-reliability operation, but device life of many hours has been the norm for a repetition rate of 13 pps.

The pulse shape is approximately cosine-squared, with a length of 4 μsec to the 50-percent points. The SCR rise-time was found to be about 1/2 μsec, and the transformer response slightly slower. (The transformer was built using copper tubing 3/16 inch in diameter as a secondary winding to handle the high current, but this gives considerable eddy-current loss.)

IX. PLASMA PROBE FOR ECCENTRIC ORBITING GEOPHYSICAL OBSERVATORY (EOGO)

During the past quarter, all flight models were completed by Hazeltine Corporation, Little Neck, Long Island, New York. The units have been tested over the environmental range of -30°C to +120°C, and all operating charcteristics were checked for interface requirements. The ground support equipment has also been built and tested by Hazeltine.

The prototype units (one proton, one electron) have been integrated at Goddard Space Flight Center to operate properly from the spacecraft signals. Vibration qualification tests have been conducted at Lincoln Laboratory at the 30-g level. The units have also been qualified at Goddard for vibration and temperature.

SURVEILLANCE TECHNIQUES
GROUP 314

I. L-BAND 84-FOOT TRACKING SYSTEM

During the period 1 October through 31 December 1962, the installation of the new 84-foot Cassegrainian antenna on the rebuilt elevation-azimuth mount was completed. The essential elements of a radar system at 1295 Mcps, including a temporary, circularly polarized horn feed, were completed by 30 November 1962, and system performance measurements started. A number of minor difficulties in the frequency synthesizing and receiving system were found and corrected by the middle of December. System performance measurements are continuing.

II. UHF 220-FOOT ZENITH SYSTEM

Measurements of ionospheric backscattered signals using the new 220-foot antenna were first made on 12 November 1962. Since that time, only a few observation periods have been available because of pressure to bring the L-band facility into operation. Nevertheless, the preliminary results are encouraging. They indicate that the electron density can be measured to at least 1000 km and the signal spectra obtained for heights up to 750 km. When the ionospheric critical frequency increases during the next sunspot maximum, these heights are likely to be raised by at least 50 percent.

The new antenna is now operating with the feedhorn relocated to the proper focal position. Measurements of the radio flux from the source in Cygnus indicate that the aperture efficiency has improved from 48.5 to 53 percent. One experimental difficulty remains that has so far prevented the full sensitivity of the system from being achieved. This difficulty is associated with the deterioration of the receiver-noise temperature caused by leakage of energy through the ATR. Thus, the system-noise temperature can be as poor as 2500°K. By suppressing the parametric amplifier during the transmitter pulse, the system temperature is reduced to 800°K. Further steps are being taken which, it is believed, will ultimately result in a 300°K system temperature.

The digital data recorder required to store the results of the spectrum measurements in a form that will permit their reduction in the CG 24 computer has been delivered. When this recorder has been integrated into the system and the receiver isolation problem has been solved, it is hoped that routine measurements can begin in earnest. Current plans call for at least one 24-hour observation period per week.

ANTENNAS
GROUP 315

I. EL CAMPO ANTENNA

It has been decided to double the size of the El Campo antenna in the east-west plane; the result will be a total antenna aperture of 1750 feet by 220 feet. The same number of dipole elements will be used, but will be arranged in a triangular, rather than square lattice. This configuration reduces the intensity of the grating lobes produced when the beam is scanned over an angle of 52° in the north-south plane. While this modification is being carried out, the coupling elements will be changed; this will produce a more uniform illumination of the array elements. These decisions are based on a thorough analysis of various space and illumination tapers.

The detailed design of this modification has begun and quotations are being obtained for the manufacture and installation of the components.

II. PROJECT WEST FORD

Four additional omnidirectional telemetry antennas for the space experimental payload have been completed and tested. Two will be used in performing environmental tests and two will be used as flight models. The switched-beam directive antenna for the orbiting signal generator has progressed to the point where a feasibility model will be assembled within the next month. The proposed antenna will consist of a multiple arrangement of 32 unidirectional beams arranged for complete spherical coverage and maximum gain at the cross-over points between adjacent beams. Each circularly polarized beam will yield a maximum gain of approximately 11 db. Improvement of the excitation circuitry might enhance the individual antenna gains to approximately 12 db. The desired antenna beam will be selected by means of a high-speed solid-state switch. A prototype design has been completed and is being evaluated.

Pending the installation of the improved tracking feed an interim feed has been installed and is undergoing operational tests at both sites. This feed consists of a long horn with a diamond aperture, circular-polarization transducer and a dual-polarization exciter. The antenna is capable of transmitting an on-axis beam, which is circularly polarized with the right-hand sense, and receiving signals which are circularly polarized with the left-hand sense.

Secondary patterns of the 60-foot West Ford-Millstone antenna, illuminated by the interim feedhorn, have been measured. The patterns are similar in all respects to those obtained previously with the original multiple-horn feed system. The 10-db sidelobe adjacent to the main beam and located in the elevation plane is present in this feed system, as it was in the previous arrangement, and has been observed again at both sites. Further investigation of and improvement in the interim feed have been discontinued because of the urgent operational requirements of other site functions. When available, the tracking feed will be installed in place of the interim feed. This change-over can be accomplished by replacing the single waveguide excitation at the input to the diamond horn by the more complicated four-port tracking exciter. The horn itself will remain in its present position.

The tracking feed system terminates in four waveguide ports which are used to excite the input section of the diamond horn. The error signals are produced at the intermediate frequency where the appropriate signals are combined to produce an effective conical scan tracking system. The prototype feed has been built and tests have been completed. The final unit is presently being constructed; following primary-pattern measurements, it will be evaluated at the Millstone site. Tests should take place during the next quarter.

Because of the increased transmitter power output and as a result of past experience obtained with the West Ford communication system, the RF transmission line will be pressurized. The pressurizing radome for the horn aperture will be a sandwich type consisting of two 1/16-inch thick sheets of Rexolite, with a center section made of 1/8-inch thick Rexolite ribs arranged in an egg-crate configuration. This design provides the desired rigidity, low reflection to the radar signals and low insertion loss. Forced-air cooling can also be provided if necessary. The final radomes will be assembled and tested during the next quarter.

The mechanical duplexer is being modified to provide an increased attenuation between the transmitter and receiver during the reception period. The blade geometry has been modified for this purpose and water cooling has been added. Final assembly, testing and installation in the equipment shelter will be accomplished in the next quarter.

A circularly polarized band-pass, band-elimination filter and several strip-line components are being developed.

III. MILLSTONE HILL RADAR

The 12-horn monopulse feed has been completely assembled, and preliminary evaluation of its performance has begun. The assembly for mounting the subreflector and the monopulse feed has been completed, and is currently being installed at the Antenna Test Range for the measurement of primary patterns.

An interim feedhorn has been installed to illuminate the 84-foot-diameter paraboloid and secondary radiation patterns and gain measurements are being conducted.

The feed system for the 220-foot zenith-looking paraboloid has been completed and the results are reported in Group Report 315-4.*

IV. PASSIVE REFLECTING SYSTEMS FOR SATELLITE COMMUNICATION

The result of a study of the use of a system of passive satellites in stationary orbits for radio communications is presented in a forthcoming Group Report. The results of a similar study have been reported in Technical Report No. 277.†

V. PROJECT 461

Group 315 assumed responsibility for designing and evaluating a tracking antenna system for Group 21. The antenna will be capable of receiving signals that are either linearly or circularly

*M. E. Devane, "Millstone Hill Zenith-Pointing Paraboloid," Group Report 315-4 [U], Lincoln Laboratory, M.I.T. (7 January 1962).

†R. N. Assaly, "A Luneburg Lens as a Passive Reflector for Satellite Communications," Technical Report No. 277 [U], Lincoln Laboratory, M.I.T. (21 August 1962), ASTIA 291781.

polarized. A 4-horn feed arrangement will be used to produce monopulse-tracking error signals The electrical design of the entire system has been completed, and detailed mechanical design is in process.

VI. COMPUTER PROGRAMS

Several new programs, one that calculates the far-field pattern of a linear array with quadratic spacing between the elements and another that calculates the E-plane diffraction pattern of a hyperboloidal reflector, have been checked out and put into operation. The results of these programs will be included in a discussion of the programs for which they were used.